Advanced EVA: Planning for Planetary Dust

Sandra Wagner
Advanced EVA Systems
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Advanced EVA: Planning for Planetary Dust

- ❑ Aim Dust Assessment
- ❑ Mars Human Precursor Measurements
- ❑ Technology Planning

Advanced Integrated Matrix (AIM) Dust Assessment

What Do We Need to Know About Martian and Lunar Dust to Write Human Support Systems Requirements?

ABSTRACT

Apollo astronauts learned first hand how problems with dust impact lunar surface missions. After three days, lunar dust contaminating on EVA suit bearings led to such great difficulty in movement that another EVA would not have been possible. Dust clinging to EVA suits was transported into the Lunar Module. During the return trip to Earth, when micro gravity was reestablished, the dust became airborne and floated through the cabin. Crews inhaled the dust and it irritated their eyes. Some mechanical systems aboard the spacecraft were damaged due to dust contamination. Study results obtained by Robotic Martian missions indicate that Martian surface soil is oxidative and reactive. Exposures to the reactive Martian dust will pose an even greater concern to the crew health and the integrity of the mechanical systems.

As NASA embarks on planetary surface missions to support its Exploration Vision, the effects of these extraterrestrial dusts must be well understood and systems must be designed to operate reliably and protect the crew in the dusty environments of the Moon and Mars.

The AIM Dust Assessment Team was tasked to identify systems that will be affected by the respective dust, how they will be affected, associated risks of dust exposure, requirements that will need to be developed, identified knowledge gaps, and recommended scientifice measurements to obtain information needed to develop requirements, and design and manufacture the surface systems that will support crew habitation in the lunar and Martian outposts.

Sandra Wagner

Jennifer Gessler
Elisa Sandvik
Carlton Allen
Debra Chowning
Bruce Duffield
Julianna Fishman

Jim Gaier
Joe Kosmo
Chiu-Wing Lam
Frances Mount
David Treat
Mike Gernhardt

ADVANCED INTEGRATION MATRIX

AN ASSESSMENT OF DUST EFFECTS ON PLANETARY SURFACE SYSTEMS TO SUPPORT EXPLORATION REQUIREMENTS

INTRODUCTION

Planetary dust leads to major system and mission failure risks. In order to mitigate the risks associated with dust, Life Support and Habitation (LSH) initiated a study to determine direction to better understand lunar and Martian dusts.

Engineering requirements are required to bound measurable quantities within the functional limits of people or technologies. Good requirements are generated through a process that involves reviewing lessons learned, identifying systems impacted by dust and other contaminates. Once requirements are written, feasibility studies need to be performed to identify technologies to meet the requirements.

This scope of this assessment was to identify applicable documents relevant to lunar and Martian dust, identify lunar and Martian human support systems that will be affected by the dusts, determine the requirements that will need to be written, perform a gap analysis to determine what information is still needed to write the requirements, and recommend experiments and measurement on the Earth, Moon, and Mars to obtain needed information.

link to document goes here

AIM Dust Assessment

Define the Problem

System Affected
Subsystem Affected
Effects on System

Risks
- ✓ Hazards
- ✓ Habitability
- ✓ Toxicity

Requirements Needed
Knowledge Gaps

Analyze the Problem

Recommendation
- ✓ Earth
- ✓ Moon
- ✓ Mars

Frame the Question

AIM Interdivisional Dust Study
Affected Systems

Advanced EVA Systems

- Airlock
- Suit Assembly
- Helmet
- PLSS Power and communications
- PLSS cooling
- PLSS O2
- PLSS Vent
- Ancillary equipment
- Structures
- Tools and hardware
- Rovers
- Displays
- Solar cells
- Windows
- Lights
- Sensors
- Cameras

Air Revitalization

- Water Recovery
- Solid Waste Processing
- Thermal Control
- Other ALS Systems

Advanced Food Systems

- Food Storage
- Food Processing
- Food Preparation.

Other Associated Systems

- GN&C
- Structures
- IVA
- Fire Detection and Suppression
- Environmental Monitoring
- Power
- Electrical and Electronics
- Communications

AIM Dust Study
Effects on System - Example

Subsystem/ Component	Effect due to Dust Exposure
Outer Garment	Dust accumulation/transfer to airlock-habitat; degradation of materials
Bearings	Seal degradation, leaks, higher spares/maintenance
Visor coatings	Scratches/severe abrasion; loss of coatings
Lighting	Reduced illumination due to dust coating illumination source

AIM Dust Study Recommendations

Measure the Things that Can Only be Measured on Mars

Measure the Things that Can Only be Measured on the Moon

Perform Simulations and Studies on Earth to Test the Effects on Human Support Systems

AIM Dust Study
Overall Recommendations (Earth)

- Develop a standard set of Lunar and Martian dust properties for future designers.
- Develop and fully characterize new Lunar and Martian soil simulants.
- Develop Lunar and Martian test chamber that closely approximates environment.
- Develop Lunar and Martian dust test programs to demonstrate system reliability.
- Obtain small quantities of actual lunar dust for critical test programs (i.e., toxicology).
- Compile information on Apollo crew’s experience with the lunar dust.
- Implement medical monitoring for astronauts exposed to Lunar and Martian dust.
- Survey and mature innovative dust mitigation technologies.

AIM Dust Study
Toxicology Recommendations (Earth)

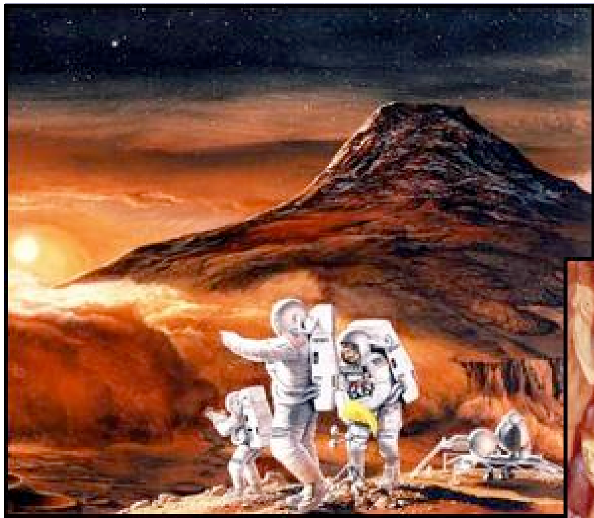
- Determine diversity of the types of dust that could be present in the area of the outpost.
- Effect of propellant byproducts on the surface of the dust.
- Particle size and shape distribution of the dust fraction below 20 microns.
- Perform toxicological studies using simulated Martian dusts (Hawaii volcanic ash) doped with appropriate oxidative chemicals.
- Establish inhalation and ingestion standards for dust in oxygen and water recovered from in-situ resources.
- Establish limits for larger dust particles for eye exposure.
- Analyze epidemiology studies of human exposures to volcanic ashes
- Review lessons learned on crew experience with the lunar dusts in the lunar command modules.

AIM Dust Study
Toxicology Recommendations (Moon)

- Collect and analyze samples in regions where dust may be different than the samples collected in the Apollo surface missions.
  - In-situ resource utilization on the polar regions that may contain water.
  - Science missions that require low interference from earth radio sources such as observation using telescopes.
- Fully characterize electrostatic levitation.
- Determine magnetic properties of the dust.
- Demonstrate airborne dust monitors and filters.

AIM Dust Study
Toxicology Recommendations (Mars)

- Measure dust loading in the Martian atmosphere under a variety of environmental conditions.
- Fully characterize the electrostatic properties of the Martian surface.
- Return Martian dust samples to Earth for full analysis well before committing humans to a Mars mission.



Mars Exploration Program Analysis Group (MEPAG)

Mars Human Precursor Science Steering Group (MHP SSG)
Measurement Team
Dust, Soil and Toxicology Focus Team

Team Dust
Strategy

- Informal “Peer” Review of AIM Assessment
- Prioritize Risks
- Recommend Measurements for MHP missions
- Prioritize Measurements

Team Dust
Risks

<u>Risk 6A:</u> If critical mechanical systems fail due to abrasion and adhesion of dust accumulated on systems, loss of science, injury or loss of crew may result.

<u>Risk 6B:</u> If critical electrical life-safety systems fail due to dust accumulation on systems, injury or loss of crew or loss of science will result.

<u>Risk 6C:</u> If critical life-safety systems fail due to corrosive effects of dust accumulated on systems, injury or loss of crew member may result.

<u>Risk 7:</u> If the crew inhales or ingests dust adverse health effects may result.

Team Dust
Investigations and Measurements

Investigation 1A.

- Characterize the particulates that could be transported to mission surfaces through the air (including both natural aeolian dust and particulates that could be raised from the martian regolith by ground operations), and that could affect hardware's engineering properties.

- Analytic fidelity sufficient to establish credible engineering simulation labs and/or performance prediction/design codes on Earth is required.

Team Dust
Investigations and Measurements

<u>Measurements</u>

a. Complete analysis
   - Shape and size distribution
   - Mineralogy
   - Electrical and thermal conductivity
   - Triboelectric and photoemission properties
   - Chemistry

b. Polarity and magnitude of charge
   - individual dust particles suspended in atmosphere
   - concentration of free atmospheric ions with positive and negative polarities.

c. The same measurements as in a) on a sample of air-borne dust collected during a major dust storm.

d. Subsets of the complete analysis described in a), and measured at different locations on Mars.

Team Dust

Investigations and Measurements

Investigation #2.

Determine the possible toxic effects of martian dust on humans.

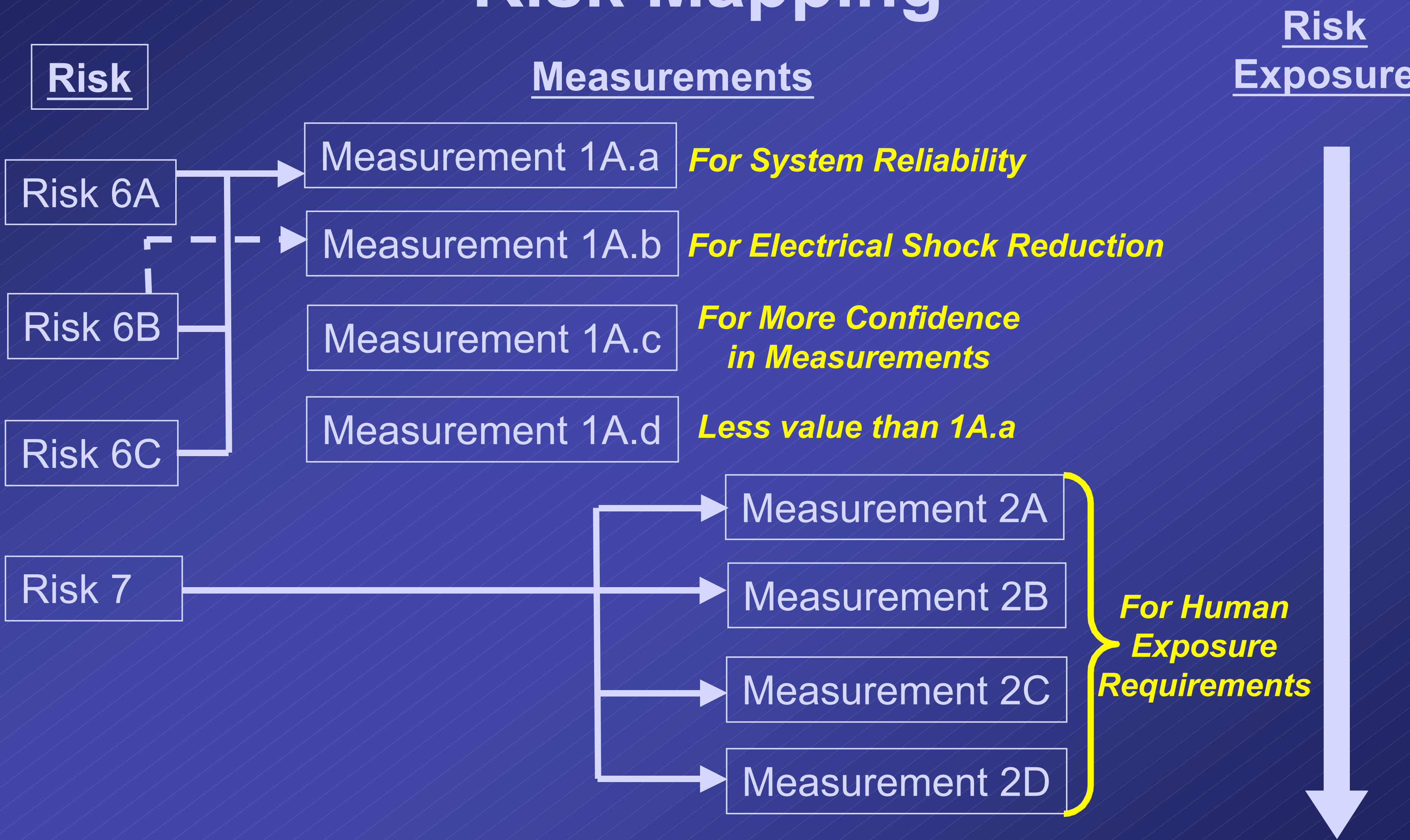
Team Dust
Investigations and Measurements

Measurements:

1. For at least one site, assay for chemicals with known toxic effect on humans.
2. Fully characterize:
   - soluble ion distributions
   - reactions that occur upon humidification
   - released volatiles
3. Analyze the shapes of martian dust grains
4. Determine if martian regolith elicits a biologic response in an animal species which is a surrogate for humans. *

* As authorized by the Institutional Animal Care and Use Committee

Team Dust
Risk Mapping



Advanced EVA
Dust Mitigation Scope

Minimize the amount of dust transferred into habitat as a result of EVA

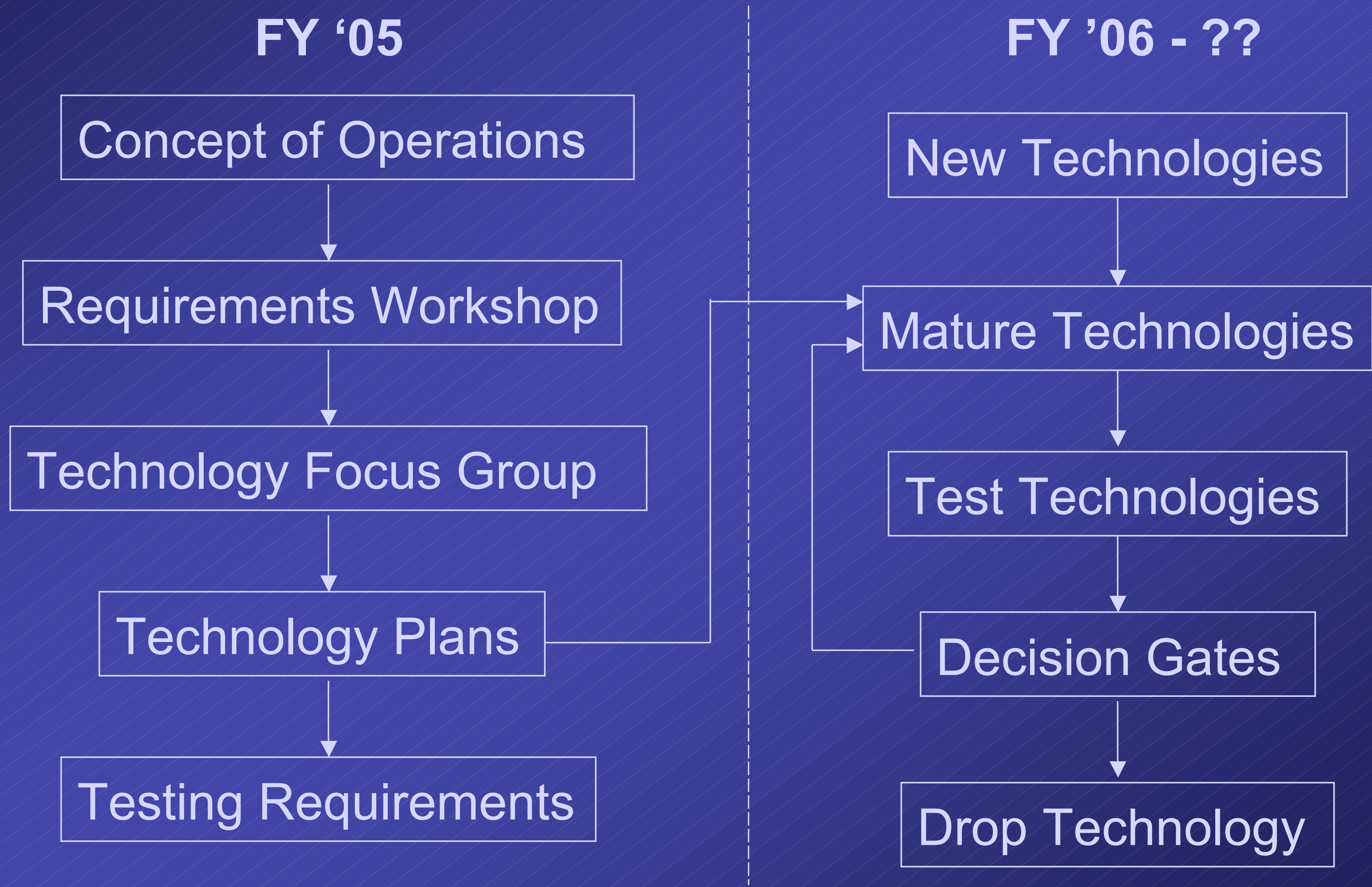
Minimize the amount of dust entering EVA suits

Maximize EVA Systems Reliability

Maximize EVA Tool and Interfaces Reliability

Advanced EVA

Dust Mitigation Technology Planning



Headed into the Cosmos